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DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

METALLOGENIC MAP OF SIGNIFICANT VOLCANOGENIC MASSIVE-SULFIDE AND RELATED LODE DEPOSITS IN ALASKA

By Warren J. Nokleberg[1], Thomas K. Bundtzen[2], Henry C. Berg[3],
David A. Brew[1], Donald Grybeck[1], Mark S. Robinson[2], and Thomas E. Smith[2]

VOLCANOGENIC MASSIVE-SULFIDE MAP SERIES
Edited by R. L. Earhart

[1] U.S. Geological Survey
[2] Alaska Division of Geological and Geophysical Surveys
[3] 115 Malvern Avenue, Fullerton, CA 92632

MISCELLANEOUS FIELD STUDIES MAP
Published by the U.S. Geological Survey, 1989

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NOKLEBERG AND OTHERS—VOLCANOGENIC MASSIVE SULFIDES, ALASKA 1:5,000,000 MAP MF-1853-C

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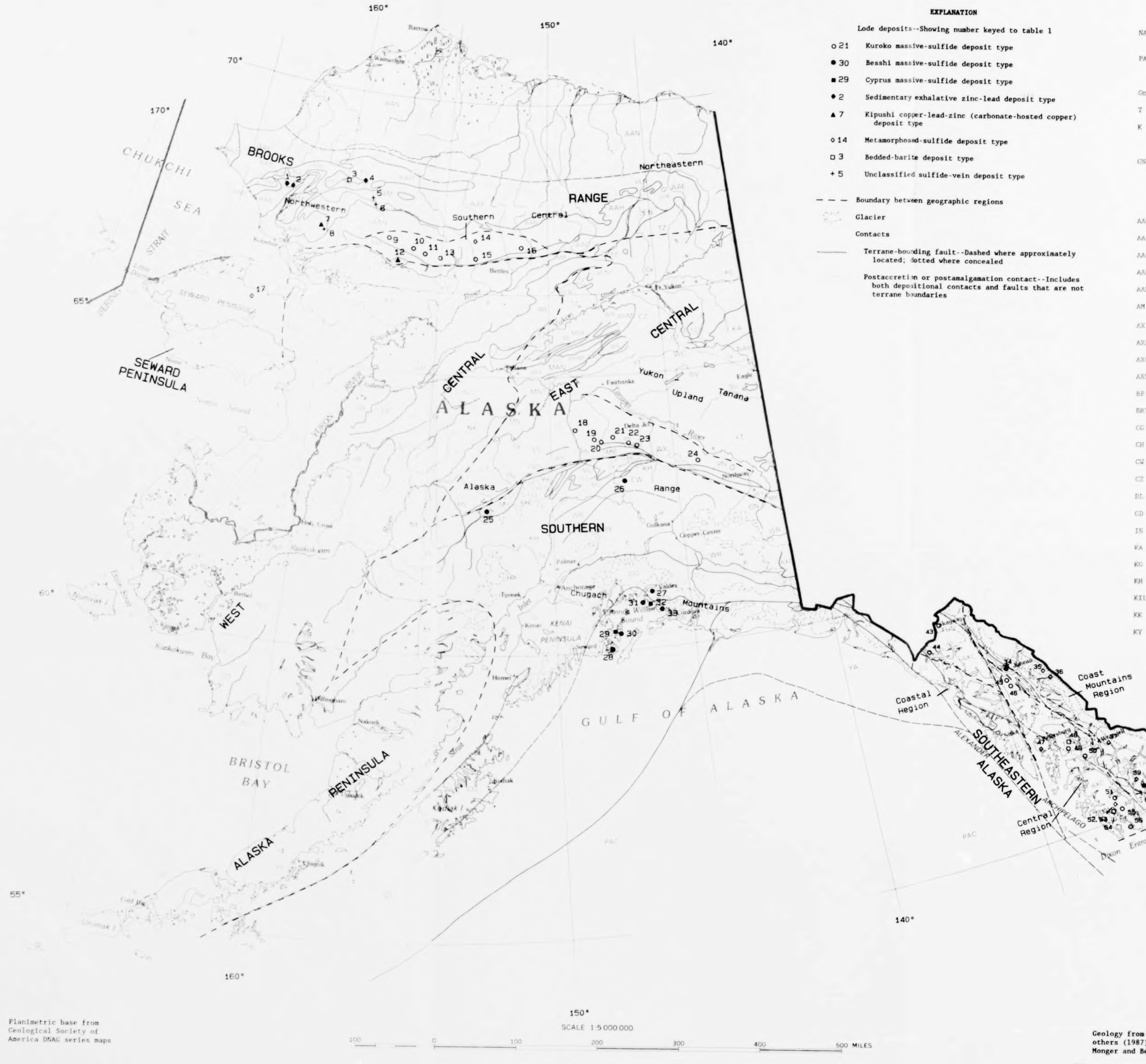

EXPLANATION

Lode deposits--Showing number keyed to table 1

○ 21	Kuroko massive-sulfide deposit type
● 30	Besshi massive-sulfide deposit type
■ 29	Cyprus massive-sulfide deposit type
◆ 2	Sedimentary exhalative zinc-lead deposit type
▲ 7	Kipushi copper-lead-zinc (carbonate-hosted copper) deposit type
○ 14	Metamorphosed-sulfide deposit type
□ 3	Bedded-barite deposit type
+ 5	Unclassified sulfide-vein deposit type

— — — Boundary between geographic regions

Glacier

Contacts

Terrane-bounding fault--Dashed where approximately located; dotted where concealed

Postaccretion or postamalgamation contact--Includes both depositional contacts and faults that are not terrane boundaries

Planimetric base from
Geological Society of
America DNAG series maps

Geology from Jones and
others (1987), and
Monger and Berg (1987)

Manuscript approved for
publication March 15, 1989

NONACCRETIONARY CONTINENTAL ROCKS AND OCEANIC PLATE

NAm	North America--Nonaccretionary Phanerozoic continental rocks of North America
PAC	Pacific plate

POSTACCRETION COVER DEPOSITS

Cz	Sedimentary and volcanic rocks (Cenozoic)
T	Sedimentary and volcanic rocks (Tertiary)
K	Sedimentary and volcanic rocks (Upper Cretaceous)

POSTAMALGAMATION OVERLAP ASSEMBLAGE

GN	Gravina-Nutzotin belt (Upper Jurassic to mid-Cretaceous)

ACCRETED TERRANES

[Arranged alphabetically by map symbol]

AAC	Coldfoot subterrane of Arctic Alaska terrane
AAD	DeLong Mountains subterrane of Arctic Alaska terrane
AAE	Endicott Mountains subterrane of Arctic Alaska terrane
AAH	Hammond subterrane of Arctic Alaska terrane
AAN	North Slope subterrane of Arctic Alaska terrane
AM	Angayucham terrane
AX	Alexander terrane, undifferentiated
AXA	Admiralty subterrane of Alexander terrane
AXC	Craig subterrane of Alexander terrane
AXN	Annette subterrane of Alexander terrane
BP	Broad Pass terrane
BRY	Baldry terrane
CG	Chugach terrane
CH	Chulitna terrane
CW	Clearwater terrane
CZ	Crazy Mountains terrane
DL	Dillinger terrane
GD	Goodnews terrane
IN	Innoko terrane
KA	Kandik River terrane
KG	Kagvik terrane
KH	Kahiltna terrane
KIL	Kilbuck terrane
KK	Kachemak terrane
KY	Koyukuk terrane
LG	Livengood terrane
MAN	Manley terrane
MK	McKinley terrane
ML	Maclaren terrane
MN	Minchumina terrane
MNK	Minook terrane
MY	Mystic terrane
NN	Nenana terrane
NX	Nixon Fork terrane
NY	Nyack terrane
PC	Porcupine terrane
PE	Peninsular terrane
PN	Pingston terrane
PW	Prince William terrane
RB	Ruby terrane
SD	Seward terrane
SE	Saint Elias terrane
SHE	Sheenjek terrane
ST	Stikinia terrane
SU	Susitna terrane
SV	Seventymile terrane
TA	Tracy Arm terrane
TG	Togiak terrane
TK	Tikchik terrane
TUS	Southern Taku terrane
TUN	Northern Taku terrane
TUC	Central Taku terrane
TZ	Tozitna terrane
VEN	Venetie terrane
WC	Woodchopper Canyon terrane
WF	West Fork terrane
WHM	White Mountains terrane
WR	Wrangellia terrane
WS	Wickersham terrane
WY	Windy terrane
YA	Yakutat terrane
YO	York terrane
YT	Yukon-Tanana terrane

Table 1.--Significant volcanogenic massive sulfide and related lode deposits in Alaska

[>, greater than; %, percent]

Map number latitude longitude	Name commodities	Type geologic host unit	Tonnage and grade production, if known
BROOKS RANGE			
Sedimentary exhalative zinc-lead and bedded barite deposits, northwestern Brooks Range			
1 68 12 163 07	Lik Zn, Pb, Ag	Sedimentary exhalative Zn-Pb. Mississippian and Pennsylvanian shale and chert	25 million tonnes grading 8.8% Zn, 3.0% Pb, 34 g/t Ag

DESCRIPTION: Disseminated and massive sphalerite, galena, pyrite, marcasite, and sparse barite in Mississippian and Pennsylvanian shale, chert, and quartz exhalite of Kuna Formation. Main deposit in zone about 2,000 m long and as much as 500 m downdip; additional sulfide minerals along strike to north and south. Sulfide horizon varies from tabular to complexly folded. Long and sinuous zone of complex and brecciated textures, possibly a line of vents, occurs within center of deposit, parallel to strike. Host rocks and deposit extensively structurally imbricated with many subhorizontal thrust faults. SOURCES: Forrest, 1983; Forrest and others, 1984.

2 68 04 162 50	Red Dog Creek Zn, Pb, Ag, Ba	Sedimentary exhalative Zn-Pb. Mississippian and Pennsylvanian shale and chert	85 million tonnes grading 17.1% Zn, 5% Pb, 82 g/t Ag

DESCRIPTION: Disseminated and massive sphalerite, galena, pyrite, and barite in Mississippian and Pennsylvanian shale, chert, and silica exhalite of the Kuna Formation. Deposit is 1,600 m long and as much as 150 m thick. Occurs near base of formation, locally subdivided into upper ore-bearing Ikalukrok unit and lower calcareous Kivalina unit (this

EDITOR'S NOTE

This map is one of several planned or published products of a study of the distribution and setting of volcanogenic massive-sulfide occurrences in the Western United States. The term "volcanogenic massive-sulfides" refers to occurrence types that are inferred to be associated with the development of ancient island arc or rift systems in a mainly subaqueous environment. Most massive-sulfide occurrences shown on this map were probably deposited in ancient island arc and rift environments and are considered to be either "proximal" or "distal" with respect to their emplacement near centers of submarine volcanic activity.

INTRODUCTION AND PURPOSE

This map and accompanying text is a compilation of the significant volcanogenic massive-sulfide and related lode deposits of Alaska as of early 1987. The map and accompanying text are parts of (1) a U.S. Geological Survey Bulletin entitled "Significant Metalliferous Lode Deposits and Placer Districts of Alaska" by Nokleberg and others (1987); and (2) a chapter of the forthcoming Alaskan volume of the Decade of North American Geology series, entitled "Metallogeny and Major Mineral Deposits of Alaska" by Nokleberg and others (1988). Both of the source articles contain previously unpublished data contributed by 56 mineral deposit and regional geologists in private industry, universities, the U.S. Geological Survey, the Alaska Division of Geological and Geophysical Surveys, the U.S. Bureau of Mines, and the authors. These data were collected principally in the last decade during a period of intense exploration for lode deposits by private industry, and, at the same time, during a period of intense mineral deposit and mineral resource assessment studies by mineral deposits geologists in universities, the U.S. Geological Survey, the U.S. Bureau of Mines, and the Alaska Division of Geological and Geophysical Surveys. Published studies of mineral deposits, cited below and in table 1, were also used to complete the summaries of the significant volcanogenic massive-sulfide and related deposits in Alaska.

This report consists of three parts. The first part is a map that shows the locations of the significant volcanogenic massive-sulfide and associated lode deposits in Alaska. The second part is this text, which provides introductory material, summarizes the classification of types of volcanogenic massive-sulfide and related lode deposits, summarizes the regional geologic setting of the significant deposits, and lists pertinent references. The third part is table 1, which provides new and timely detailed summaries of the significant volcanogenic massive-sulfide and related lode deposits in Alaska as of early 1987. In this and related reports, the term "significant deposits" is defined as all metalliferous mines, prospects, deposits, or occurrences that we judge to be important, on the basis of size, geological importance, or scientific interest. For each significant deposit, table 1 lists the geographic coordinates, common names, major metals or commodities, a mineral deposit type, the host-rock geology, data on tonnage, grade, and production, if known, and sources of information.

One result of the geologic mapping and associated geologic studies of Alaska in the last decade is the recognition of numerous fault-bounded assemblages of rocks designated as tectonostratigraphic terranes. Proponents of this concept suggest that most of Alaska consists of a collage of such terranes (Jones and others, 1987; Monger and Berg, 1987). Maps from these authors are used as the geologic base for the map in this report. In the text, the rock units in each tectonostratigraphic terrane are used to describe the geologic setting of the significant volcanogenic massive-sulfide and related lode deposits in Alaska.

CLASSIFICATION OF TYPES OF VOLCANOGENIC MASSIVE-SULFIDE AND RELATED LODE DEPOSITS

The significant volcanogenic massive-sulfide and related lode deposits described in this report are classified into seven distinct models or deposit types. These deposit types, summarized below, are Kuroko massive sulfide, Besshi massive sulfide, Cyprus massive sulfide, sedimentary exhalative zinc-lead, Kipushi copper-lead-zinc (carbonate-hosted copper), metamorphosed massive sulfide, and bedded barite. As a group, these deposit types are generally interpreted by most investigators to have been deposited in ancient submarine island-arc, submerged continental-margin arc, or rift systems.

This classification of mineral deposits is mainly derived from the mineral deposit models of specialists as compiled in Cox and Singer (1986), and to a lesser degree from earlier studies of Erickson (1982) and Cox (1983a, b). For a few lode deposits, lack of data precludes classification into a specific mineral deposit type. For these deposits, a brief description of the deposit is enclosed in parentheses under the type heading in table 1. The mineral deposit models used in this report and in Cox and Singer (1986) consist of both descriptive and genetic information that is systematically arranged to describe the essential properties of a class of mineral deposits. Some models are descriptive (empirical), in which case the various attributes are recognized as essential, even though their relationships are unknown. For additional information on the methodology of mineral deposit models, the reader is referred to the discussion by Cox and Singer (1986).

Kuroko Massive-Sulfide Deposit
(D.A. Singer *in* Cox and Singer, 1986)

This deposit type consists of volcanogenic, stratiform massive to disseminated sulfide minerals in felsic to intermediate marine volcanic and pyroclastic rocks and interbedded sedimentary rocks, and a subjacent stringer (stockwork) system. The volcanic rocks are mainly rhyolite and dacite, but contain subordinate basalt and andesite. The depositional environment is mainly hot springs related to marine volcanism in island-arc or extensional regimes. The deposit minerals include pyrite, chalcopyrite, sphalerite, and lesser galena, tetrahedrite, tennantite, gold, and magnetite. Alteration products include zeolite minerals, montmorillonite, silica in various forms, chlorite, and sericite. Notable examples of Kuroko massive-sulfide deposits in Alaska are the Arctic, Smucker, and Sun deposits in the Brooks Range, the WTF, Red Mountain deposit, and deposits in the Delta district in east-central Alaska, and the Greens Creek, Glacier Creek, Khayyam, and Orange Point deposits in southeastern Alaska.

Besshi Massive-Sulfide Deposit
(D.P. Cox *in* Cox and Singer, 1986)

This deposit type consists of thin, sheet-like bodies of massive to well-laminated pyrite, pyrrhotite, and chalcopyrite, and less abundant sulfide minerals, within thinly laminated clastic sedimentary rocks and mafic tuff. The rock types are mainly marine clastic sedimentary rocks, lesser amounts of basalt and andesite tuff and breccia, and local black shale and red chert. The depositional environment is uncertain, but may be submarine hot springs related to submarine basaltic volcanism. Associated minerals include sphalerite and lesser magnetite, galena, bornite, and tetrahedrite. Gangue includes quartz, carbonate minerals, albite, white mica, and chlorite. Alteration is difficult to recognize in some places because of metamorphism. Notable examples of Besshi massive-sulfide deposits in Alaska are the Midas, Latouche, Beatson, Ellamar, and Fidalgo-Alaska mines in the Prince William Sound region of southern Alaska.

The northwestern Brooks Range contains a belt of large sedimentary exhalative zinc-lead and bedded-barite deposits that extends along strike for more than 200 km (map, table 1). The largest zinc-lead-silver deposits are Lik, which contains an estimated 25 million tonnes of ore (Forrest, 1983; Forrest and others, 1984), and Red Dog Creek, which contains an estimated 85 million tonnes of ore and ranks within the top 20 percent, based on size, of known deposits of this type (Moore and others, 1986). Both deposits have high concentrations of zinc, lead, and silver (table 1). A somewhat similar deposit at Drenchwater Creek is in both sedimentary and volcaniclastic rocks (table 1). The Nimiuktuk bedded-barite deposit contains an estimated 1.5 million tonnes of barite (table 1). Substantial potential exists for finding additional deposits in the northwestern Brooks Range (Nokleberg and Winkler, 1982; Lange and others, 1985).

The sedimentary exhalative zinc-lead and bedded-barite deposits in the northwestern Brooks Range are in a tectonically disrupted and strongly folded assemblage of Mississippian and Pennsylvanian chert, shale, limestone turbidite, minor tuff, and sparse intermediate to silicic volcanic rocks, mainly keratophyre, named the "Kuna Formation" (Mull and others, 1982). The Kuna Formation forms the basal unit of the Kagvik sequence (Churkin and others, 1979) and the Kagvik terrane (Jones and others, 1987). This unit, as well as younger late Paleozoic and early Mesozoic chert and shale, are interpreted either as a deep-water, allochthonous oceanic assemblage (Churkin and others, 1979; Nokleberg and Winkler, 1982; Lange and others, 1985) or as an assemblage deposited in an intracratonic basin (Mull and others, 1982; Mayfield and others, 1983). The sedimentary exhalative zinc-lead and bedded-barite deposits are interpreted to have formed either in an incipient submarine continental-margin arc or in the early stages of a long-lived, sediment-starved, epicontinental basin (Nokleberg and others, 1987, 1988).

The eastern part of the northwestern Brooks Range contains a belt of sulfide-vein deposits: Story Creek, Whoopee Creek, Frost, and Omar (map, table 1). These sulfide-vein deposits are summarized in this report because they may be, in part, remobilized from volcanogenic massive-sulfide deposits. The sulfide-vein deposits generally consist of sphalerite and galena, minor quartz, and minor carbonate gangue in veins and fractures that cut the Mississippian Kayak Shale of the Endicott Group at the Story Creek and Whoopee Creek deposits and in dolomite and limestone of the Baird Group at Frost. The veins and fractures are in linear zones from 1.5 to 3 km long that cross tightly folded strata; an epigenetic origin is indicated (I.F. Ellersieck and J.M. Schmidt, written commun., 1985). No tonnage and grade data are available. Insufficient data preclude assignment of some of these deposits to a specific mineral deposit type. The Omar deposit (table 1) consists of disseminated to massive chalcopyrite and other sulfide minerals in veinlets, stringers, and blebs in brecciated Ordovician to Devonian dolomite and limestone of the Baird Group (Folger and Schmidt, 1986), and it is classified as a Kipushi copper-lead-zinc deposit (table 1). The Endicott Group, which hosts the Story Creek and Whoopee Creek deposits, forms part of the Brooks Range allochthon (Mayfield and others, 1983) and is part of the Endicott Mountains subterrane (map). The Baird Group, which hosts the Frost deposit, forms part of the Kelly River allochthon (Mayfield and others, 1983) and is part of the DeLong Mountains subterrane (map).

An extensive belt of major Kuroko massive-sulfide deposits and one Kipushi copper-lead-zinc deposit is aligned along an east-west trend for about 260 km along the southern flank of the Brooks Range (map, table 1). The largest deposits are in the Ambler district (Hitzman and others, 1982): the Arctic, which contains an estimated 32 million tonnes of ore (Schmidt, 1983, 1986), and the Ruby Creek, which contains an estimated 91 million tonnes of ore averaging 1.2 percent Cu (Hitzman, 1986) (table 1). Other Kuroko massive-sulfide deposits in the belt are the Smucker, BT, Jerri Creek, Roosevelt Creek, Sun, and Michigan Creek deposits (map, table 1) (Hitzman and others, 1982). The Ann deposit in the southern Brooks Range may be either a polymetallic vein or a metamorphosed sulfide deposit (table 1).

The Kuroko massive-sulfide deposits in the Ambler district are in or adjacent to submarine mafic and felsic metavolcanic rocks and associated carbonate, pelitic, and graphitic metasedimentary rocks of the Devonian and Mississippian Ambler sequence (Hitzman and others, 1982). The Ambler sequence, along with the Beaver Creek Phyllite, Bornite Marble, Mauneluk Schist, and Anirak Schist, forms the informally named "schist belt" of the southern Brooks Range (Hitzman and others, 1982). The Ambler sequence is generally multiply deformed and exhibits metamorphism of both greenschist and blueschist facies (Hitzman and others, 1982). The deposits are in the Ambler sequence, which forms the southern part of the Hammond subterrane (map). Most workers in the southern Brooks range favor an origin within a continental-margin rift rather than in an island-arc for these Kuroko massive-sulfide deposits. The Ruby Creek deposit, classified as a Kipushi copper-lead-zinc deposit, is genetically related to Devonian submarine volcanism (Hitzman, 1986). Bernstein and Cox (1986) stress the significance of carrolite and the copper-germanium sulfide renierite in the Ruby Creek deposit as a link to the dolomite-hosted deposits at Kipushi and Zaire (Cox and Singer, 1986).

SEWARD PENINSULA

The Seward Peninsula contains a metamorphosed sulfide deposit in the northeastern part of the peninsula at Hannum Creek (map, table 1). The deposit consists of blebs, stringers, massive lenses, and disseminations of galena, pyrite, sphalerite, and barite parallel to layering in Paleozoic quartz-mica schist and marble that are part of the Nome Group (mixed unit of Till, 1984). The deposit is interpreted as a metamorphosed laminated exhalite, possibly a former sedimentary exhalative zinc-lead deposit (J.A. Briskey, written commun., 1985).

EAST-CENTRAL ALASKA - NORTHERN ALASKA RANGE

East-central Alaska contains an extensive suite of Kuroko massive-sulfide deposits in the northern Alaska Range: Liberty Bell, Sheep Creek, Anderson Mountain, WTF, Red Mountain, Miyaoka, Hayes Glacier, McGinnis Glacier, and deposits in the Delta district (table 1). The Kuroko massive-sulfide deposits extend for 250 km along strike on the northern flank of the Alaska Range (map), and constitute one of the longer belts of massive-sulfide deposits in Alaska. Substantial base and precious metals are present in these deposits (Nokleberg and others, 1987). The Liberty Bell deposit contains an estimated 91,000 tonnes grading 10 percent As, 2 percent Cu, and 34 g/t Au. The WTF and Red Mountain deposits contain an estimated 1.10 million tonnes grading 0.15 percent Cu, 2.5 percent Pb, 7.9 percent Zn, 270 g/t Ag, and 1.9 g/t Au. The largest deposit in the Delta district contains an estimated 18 million tonnes grading 0.3-0.7 percent Cu, 1-3 percent Pb, 3-6 percent Zn, 34-100 g/t Ag, and 1-3.4 g/t Au. Deposits in this belt have been discovered mainly within the last 10 years. Potential exists for the discovery of additional deposits.

The Kuroko massive-sulfide deposits in the northern Alaska Range are in Devonian or older polymetamorphosed, polydeformed, submarine metavolcanic rocks, pelitic schist, calc-schist, and marble. Very few or no gneissic granitic rocks occur (Aleinikoff and Nokleberg, 1985; Nokleberg and Aleinikoff, 1985; Nokleberg and Lange, 1985). This assemblage is interpreted as the upper structural and stratigraphic level of the Yukon-Tanana terrane (Nokleberg and Aleinikoff, 1985). Metamorphic grade ranges from amphibolite facies at depth to greenschist facies at higher levels (Nokleberg and Aleinikoff, 1985; Nokleberg and others, 1986). Locally abundant Cretaceous(?) gabbro to diorite dikes and sills crosscut schistosity and foliation in the sequence. Structurally overlying these older rocks are metasedimentary and metavolcanic rocks of the Precambrian or early Paleozoic Keevy Peak Formation and Middle Devonian to Lower Mississippian Totatlanika Schist (Wahrhaftig, 1968; Gilbert and Bundtzen, 1979). The Kuroko massive-sulfide deposits are interpreted as having formed during Devonian submarine volcanism (Nokleberg and others, 1987, 1988).

SOUTHERN ALASKA

The southern Alaska Range, in southern Alaska, contains two significant Besshi massive-sulfide deposits, Shellabarger Pass to the southwest and Denali to the east (map, table 1). The Shellabarger Pass deposit consists of a very fine grained mixture of mainly pyrite and marcasite and lesser sphalerite, chalcopyrite, galena, and pyrrhotite in carbonate-rich beds and as fracture fillings in Triassic or Jurassic chert and siltstone and associated pillow basalt (Reed and Eberlein, 1972). The Denali deposit consists of stratiform bodies of very fine grained and thin-layered chalcopyrite and minor pyrite in thin-bedded, shale-rich calcareous argillite enclosed in the Upper Triassic Nikolai Greenstone (Stevens, 1971; Seraphim, 1975).

In the eastern Chugach Mountains, Besshi and Cyprus massive-sulfide deposits in the Prince William Sound district along the eastern and northern margins of the Gulf of Alaska are Beatson, Copper Bullion, Ellamar, Fidalgo-Alaska, Knight Island, Latouche, Midas, Pandora, Schlosser, Standard Copper, and Threeman (map, table 1). Midas, the northernmost deposit, is in the southern part of the Valdez Group, which in this area consists of metamorphosed and deformed Upper Cretaceous flysch and greenstone derived from basalt. The other deposits to the south are in the Orca Group. Most of the deposits are classified as sediment-hosted Besshi massive-sulfide deposits; Knight Island, Standard Copper, and Threeman are basalt-hosted deposits classified as Cyprus massive-sulfide deposits (table 1). The Orca Group, which hosts most of the deposits, consists of a strongly deformed, thick assemblage of Paleocene and Eocene graywacke, argillite, minor conglomerate, pillow basalt, basaltic tuff, sills, and dikes (Winkler and Plafker, 1981), part of the Prince William terrane (map).

SOUTHEASTERN ALASKA

The geology of southeastern Alaska is varied and complex. In this report, southeastern Alaska is divided into three north-northwest-trending regions: the Coast Mountains region, central southeastern Alaska, and coastal southeastern Alaska (map). The Coast Mountains region consists of the informally named Coast plutonic-metamorphic complex of Brew and Ford (1984a, b), which is approximately equivalent, from east to west, to part of the Stikinia terrane, to all of the Tracy Arm and Taku terranes, and to part of the Gravina-Nutzotin belt (Monger and Berg, 1987). Central southeastern Alaska consists of the Alexander belt (Brew and others, 1984), which is approximately equivalent to the Alexander terrane (Monger and Berg, 1987). Coastal southeastern Alaska consists of the Kelp Bay Group and similar unnamed rocks, both part of the Wrangellia terrane (Monger and Berg, 1987), and the Sitka Graywacke and similar unnamed rocks, part of the Chugach terrane (Monger and Berg, 1987).

The mineral occurrences, deposits, and mines within this complex geologic region are likewise a complex, including a variety of volcanogenic massive-sulfide deposits (Berg and others, 1981; Berg, 1984). The Coast Mountains region contains an extensive suite of metamorphosed sulfide deposits and one Besshi massive-sulfide deposit. Central southeastern Alaska contains extensive suites of Kuroko massive sulfide, bedded barite, and metamorphosed sulfide deposits. Coastal southeastern Alaska contains no known significant volcanogenic massive-sulfide or related lode deposits.

Coast Mountains Region

Metamorphosed sulfide deposits present in the Coast Mountains region are Sweetheart Ridge, Sumdum, Groundhog Basin, Alamo, Mahoney, Moth Bay, Reliance, and Red River (map, table 1). The metamorphosed sulfide deposits are widespread and occur along a strike length of about 300 km. The deposits consist of stratabound, massive to disseminated sulfide minerals hosted by moderately to highly metamorphosed and deformed volcanic and

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DESCRIPTION: Disseminated and massive sphalerite, galena, pyrite, marcasite, and sparse barite in Mississippian and Pennsylvanian shale, chert, and quartz-exhalite of Kuna Formation. Main deposit in zone about 2,000 m long and as much as 500 m downdip; additional sulfide minerals along strike to north and south. Sulfide horizon varies from tabular to complexly folded. Long and sinuous zone of complex and brecciated textures, possibly a line of vents, occurs within center of deposit, parallel to strike. Host rocks and deposit extensively structurally imbricated with many subhorizontal thrust faults. SOURCES: Forrest, 1983; Forrest and others, 1984.

2. 68 04 162 50	Red Dog Creek. Zn, Pb, Ag, Ba	Sedimentary exhalative Zn-Pb. Mississippian and Pennsylvanian shale and chert	85 million tonnes grading 17.1% Zn, 5% Pb, 82 g/t Ag

DESCRIPTION: Disseminated and massive sphalerite, galena, pyrite, and barite in Mississippian and Pennsylvanian shale, chert, and silica exhalite of the Kuna Formation. Deposit is 1,600 m long and as much as 150 m thick. Occurs near base of formation, locally subdivided into upper ore-bearing Ikalukrok unit and lower calcareous Kivalina unit (this study). Latter forms stratigraphic footwall for deposits. Barite-rich lenses as much as 30 m thick locally cap deposit. Main occurrences are disseminated sulfide minerals in organic-rich siliceous shale, coarse-grained sulfide veins, fine-grained fragmental-textured to indistinctly bedded sulfide minerals, and silica exhalite lenses. Minor hydrothermal alteration: silicification and decarbonatization of shale. Small propylitically altered dioritic plug or hydrothermally altered pyroxene andesite flow occurs at north end of deposit. Host rocks and deposit extensively structurally imbricated with many subhorizontal thrust faults. Graywacke of the Jurassic and Lower Cretaceous Okpikruak Formation structurally underlies deposit. SOURCES: Tailleur, 1970; Plahuta, 1978; Booth, 1983; J.T. Plahuta, L.E. Young, J.S. Modene, and D.W. Moore, written commun., 1984; Lange and others, 1985; Moore and others, 1986.

3. 68 24 159 56	Nimiuktuk. Barite	Bedded barite.	About 1.5 million tonnes barite

DESCRIPTION: Massive, nearly pure barite in small isolated hill about 7-10 m high, 40 m wide, and 60 m long. Stratigraphic contacts not exposed; nearest units are dark shale and chert of the Mississippian and Pennsylvanian Kuna Formation and shale and graywacke of the Lower Cretaceous Okpikruak Formation. Altered Mississippian(?) andesite crops out about 180 m from barite. Volume determined by gravity survey and model. SOURCES: Mayfield and others, 1979; Barnes and others, 1982.

4. 68 34 158 41	Drenchwater. Zn, Pb, Ag	Sedimentary exhalative Zn-Pb and (or) Kuroko massive sulfide. Mississippian shale, chert, tuff	Grab samples containing >1% Zn, >2% Pb, 150 g/t Ag

DESCRIPTION: Disseminated and massive sphalerite, galena, pyrite, and barite in Mississippian shale, chert, tuff, and quartz-exhalite of the Kagvik sequence. Locally abundant volcanic sandstone and keratophyre. Sulfides occur as disseminations in chert, as disseminations and massive aggregates in quartz-exhalite, and as sparse, remobilized disseminations in sulfide-quartz veins crosscutting cleavage in shale and chert. Local extensive hydrothermal alteration of chert and shale with extensive replacement by kaolinite, montmorillonite, sericite, prehnite, fluorite, actinolite, chlorite, calcite, and quartz. Deposit as much as 1,800 m long and as much as 50 m thick. Host rocks and deposit extensively faulted and structurally imbricated with many thrust faults dipping moderately south. SOURCES: Tailleur and others, 1977; Nokleberg and Winkler, 1982; Lange and others, 1985.

Unclassified vein and Kipushi copper-lead-zinc deposits, northwestern Brooks Range

5. 68 22 157 56	Story Creek Pb, Zn, Ag, Au	Pb-Zn-Au-Ag vein. Mississippian sandstone, siltstone, and shale	Grab samples containing as much as 1.5-34% Pb, 1.5-50% Zn, 35-940 g/t Ag, and 1.2 g/t Au.

DESCRIPTION: Crustified sphalerite and galena in crosscutting quartz veins occurring in tightly folded and faulted sandstone, siltstone, and shale of the Mississippian Kayak Shale, part of Brooks Range allochthon. Maximum width of float zone about 30-40 m. Discontinuous outcrops and associated float along a linear trend about 3,000 m long across tightly folded strata, indicating replacement origin in Late Jurassic or younger time. SOURCES: Ellersieck and others, 1982; Mayfield and others, 1983; J.M. Schmidt and I.F. Ellersieck, written commun., 1985.

6. 68 14 157 51	Whoopee Creek. Zn, Ag, Au	Zn-Ag-Au vein. Mississippian sandstone, siltstone, and shale	Grab samples containing as much as 44% Zn, 458 g/t Ag, 4.4 g/t Au

DESCRIPTION: Fracture zones containing siltstone breccia with matrix of galena, sphalerite, quartz and minor carbonate hosted in tightly folded and faulted sandstone, siltstone, and shale of the Mississippian Kayak Shale. Fracture zone about 6 m long. Discontinuous outcrops and associated float along a linear trend having minimum length of 1,500 m across tightly folded strata, indicating replacement origin in Late Jurassic or younger time. SOURCES: Ellersieck and others, 1982; I.F. Ellersieck, written commun., 1985.

7. 67 39 161 50	Omar. Cu, Pb, Zn, Ag, Co	Kipushi Cu-Pb-Zn. Ordovician to Devonian dolomite and limestone	Grab samples containing 15.3% Cu, 0.144% Pb, 0.95% Zn, 20 g/t Ag

DESCRIPTION: Disseminated to massive chalcopyrite, bornite, lesser chalcocite, minor tennantite-tetrahedrite, very minor galena, supergene copper carbonates, and iron-oxide minerals occurring in veinlets, irregular stringers, or as blebs in brecciated host dolomite. Gangue of dolomite, calcite, and quartz anomalously high in Zn and Co. Sulfide zone about 1 km long occurs along north-northwest-trending fractures and veins. Local solution breccia. Local remobilization of sulfide minerals into fractures. Local faulted and brecciated gossan. Host rocks of Ordovician to Devonian dolomite and limestone of the Baird Group, part of Kelly River allochthon. Host rocks strike north-northeast, dips vary from gentle to vertical. Local isoclinal minor folds. SOURCES: Degenhart and others, 1978; Jansons, 1982; Mayfield and others, 1983; I.F. Ellersieck, written commun., 1985; Folger and Schmidt, 1986.

8. 67 28 161 35	Frost. Cu, Zn, Pb, barite	Cu-Zn-Pb-Ba vein. Ordovician to Devonian dolomite and limestone	As much as 0.9 million tonnes barite, possible 9 million tonnes. One vein contained 13.2% Zn, 0.5% Cu, 21% barite

DESCRIPTION: Chalcopyrite and galena in sinuous quartz-calcite-barite veins, and lenses and pods of barite at least 30 m long and 10 m thick. Veins, lenses, and pods crosscut Ordovician to Devonian dolomite and limestone for minimum distance of 1.6 km. Calcite-

METALLOGENIC MAP OF SIGNIFICANT VOLCANOGENIC MASSIVE-SULFIDE AND RELATED LODE DEPOSITS IN ALASKA

By

Warren J. Nokleberg[1], Thomas K. Bundtzen[2], Henry C. Berg[3], David A. Brew[1],
Donald Grybeck[1], Mark S. Robinson[2], and Thomas E. Smith[2]

VOLCANOGENIC MASSIVE-SULFIDE MAP SERIES

Edited by R. L. Earhart

[1] U.S. Geological Survey
[2] Alaska Division of Geological and Geophysical Surveys
[3] 115 Malvern Avenue, Fullerton, CA 92632

1989

and others, 1987; Monger and Berg, 1987). Maps from these authors are used as the geologic base for the map in this report. In the text, the rock units in each tectonostratigraphic terrane are used to describe the geologic setting of the significant volcanogenic massive-sulfide and related lode deposits in Alaska.

CLASSIFICATION OF TYPES OF VOLCANOGENIC MASSIVE-SULFIDE AND RELATED LODE DEPOSITS

The significant volcanogenic massive-sulfide and related lode deposits described in this report are classified into seven distinct models or deposit types. These deposit types, summarized below, are Kuroko massive sulfide, Besshi massive sulfide, Cyprus massive sulfide, sedimentary exhalative zinc-lead, Kipushi copper-lead-zinc (carbonate-hosted copper), metamorphosed massive sulfide, and bedded barite. As a group, these deposit types are generally interpreted by most investigators to have been deposited in ancient submarine island-arc, submerged continental-margin arc, or rift systems.

This classification of mineral deposits is mainly derived from the mineral deposit models of specialists as compiled in Cox and Singer (1986), and to a lesser degree from earlier studies of Erickson (1982) and Cox (1983a, b). For a few lode deposits, lack of data precludes classification into a specific mineral deposit type. For these deposits, a brief description of the deposit is enclosed in parentheses under the type heading in table 1. The mineral deposit models used in this report and in Cox and Singer (1986) consist of both descriptive and genetic information that is systematically arranged to describe the essential properties of a class of mineral deposits. Some models are descriptive (empirical), in which case the various attributes are recognized as essential, even though their relationships are unknown. For additional information on the methodology of mineral deposit models, the reader is referred to the discussion by Cox and Singer (1986).

Kuroko Massive-Sulfide Deposit
(D.A. Singer in Cox and Singer, 1986)

This deposit type consists of volcanogenic, stratiform massive to disseminated sulfide minerals in felsic to intermediate marine volcanic and pyroclastic rocks and interbedded sedimentary rocks, and a subjacent stringer (stockwork) system. The volcanic rocks are mainly rhyolite and dacite, but contain subordinate basalt and andesite. The depositional environment is mainly hot springs related to marine volcanism in island-arc or extensional regimes. The deposit minerals include pyrite, chalcopyrite, sphalerite, and lesser galena, tetrahedrite, tennantite, gold, and magnetite. Alteration products include zeolite minerals, montmorillonite, silica in various forms, chlorite, and sericite. Notable examples of Kuroko massive-sulfide deposits in Alaska are the Arctic, Smucker, and Sun deposits in the Brooks Range, the WTF, Red Mountain deposit, and deposits in the Delta district in east-central Alaska, and the Greens Creek, Glacier Creek, Khayyam, and Orange Point deposits in southeastern Alaska.

Besshi Massive-Sulfide Deposit
(D.P. Cox in Cox and Singer, 1986)

This deposit type consists of thin, sheet-like bodies of massive to well-laminated pyrite, pyrrhotite, and chalcopyrite, and less abundant sulfide minerals, within thinly laminated clastic sedimentary rocks and mafic tuff. The rock types are mainly marine clastic sedimentary rocks, lesser amounts of basalt and andesite tuff and breccia, and local black shale and red chert. The depositional environment is uncertain, but may be submarine hot springs related to submarine basaltic volcanism. Associated minerals include sphalerite and lesser magnetite, galena, bornite, and tetrahedrite. Gangue includes quartz, carbonate minerals, albite, white mica, and chlorite. Alteration is difficult to recognize in some places because of metamorphism. Notable examples of Besshi massive-sulfide deposits in Alaska are the Midas, Latouche, Beatson, Ellamar, and Fidalgo-Alaska mines in the Prince William Sound region of southern Alaska.

Cyprus Massive-Sulfide Deposit
(D.A. Singer in Cox and Singer, 1986)

This deposit type consists of massive sulfide minerals in pillow basalt. The depositional environment consists of submarine hot springs along an axial graben in oceanic or backarc spreading ridges or hot springs related to submarine volcanoes in seamounts. The deposit minerals consist mainly of pyrite, chalcopyrite, sphalerite, and lesser marcasite and pyrrhotite. The sulfide minerals are in pillow basalt that is associated with tectonized ophiolite-related dunite, harzburgite, gabbro, sheeted diabase dikes, and fine-grained sedimentary rocks, all part of an ophiolite assemblage. Beneath the massive-sulfide ore in places is stringer or stockwork pyrite, pyrrhotite, minor chalcopyrite, and sphalerite. The sulfide minerals are locally brecciated and recemented. Alteration in the stringer zone consists of abundant quartz, chalcedony, chlorite, and minor illite and calcite. Some deposits are overlain by iron-rich and manganese-poor ochre. Notable examples of Cyprus massive-sulfide deposits in Alaska are the Knight Island and Threeman mines and the Copper Bullion deposit, all in coastal southern Alaska.

Sedimentary Exhalative Zinc-Lead Deposit
(J.A. Briskey in Cox and Singer, 1986)

This deposit type consists of stratiform, massive to disseminated sulfide minerals in sheet-like or lens-like tabular bodies that are interbedded with euxinic marine sedimentary rocks including dark shale, siltstone, limestone, chert, and sandstone. The depositional environment consists mainly of marine epicratonic embayments and intracratonic basins, and associated smaller, local restricted basins. The deposit minerals include pyrite, pyrrhotite, sphalerite, galena, barite, and chalcopyrite. Extensive alteration minerals may be present, including stockwork and disseminated sulfide minerals (previously mentioned), silica in various forms, albite, and chlorite. Notable examples of sedimentary exhalative zinc-lead deposits in Alaska are the Lik and Red Dog Creek deposits in the northwestern Brooks Range.

Kipushi Copper-Lead-Zinc (Carbonate-Hosted Copper) Deposit
(D.P. Cox and L.R. Bernstein in Cox and Singer, 1986)

This deposit type consists of stratabound, massive sulfide minerals hosted mainly by dolomitic breccia. The depositional environment consists mainly of strong fluid flow along faults or karst(?)-breccia zones. Generally no rocks of unequivocal igneous origin are related to the deposit. The deposit minerals include pyrite, bornite, chalcocite, chalcopyrite, carrollite, sphalerite, and tennantite, and minor renierite and germanite. Local dolomite, siderite, and silica in various forms, all as alteration products, may be present. Notable examples of carbonate-hosted copper deposits in Alaska are the Ruby Creek and Omar deposits in the Brooks Range. In parts of Alaska, Kipushi copper-lead-zinc deposits such as that at Ruby Creek are generally associated with Kuroko massive-sulfide deposits such as those nearby to the north in the Ambler district.

Metamorphosed Sulfide Deposit
(Nokleberg and others, 1987)

This deposit type consists of stratabound, massive to disseminated sulfide minerals hosted by moderately to highly metamorphosed and deformed metavolcanic or metasedimentary rocks. Metamorphism and deformation have obscured protoliths of host rocks and deposits so as to preclude classification into more specific deposit types. The interpreted host rocks for these deposits are mainly felsic to mafic metavolcanic rocks and metasedimentary or metavolcanic schist and gneiss. The deposit minerals include chalcopyrite, sphalerite, galena, gold, and bornite, in some cases with pyrite, magnetite, and hematite. Alteration is usually difficult to recognize because of metamorphism. These deposits are mainly in regional metamorphic rocks in southeastern Alaska, either in the informally named Coast plutonic-metamorphic complex of Brew and Ford (1984a, b) or in the Alexander belt. Notable examples of metamorphosed sulfide deposits are the Sweetheart Ridge, Sumdum, Groundhog Basin, and Moth Bay deposits, all in southeastern Alaska.

Bedded-Barite Deposit
(G.J. Orris in Cox and Singer, 1986)

This deposit type consists of stratiform, massive barite interbedded with marine, chert-rich and calcareous sedimentary rocks, mainly dark chert, shale, mudstone, and dolomite. The depositional environment consists mainly of epicratonic marine basins or embayments, or submerged volcanic arcs, and associated smaller local basins. Many bedded-barite deposits are associated with sedimentary exhalative zinc-lead or Kuroko massive-sulfide deposits. Alteration consists of secondary barite veining and local, weak to moderate sericite replacement. Associated minerals include minor witherite, pyrite, galena, and sphalerite. Notable examples of bedded-barite deposits in Alaska are the Nimiuktuk deposit in the northwestern Brooks Range and the Castle Island mine in southeastern Alaska.

ABBREVIATIONS AND CONVERSION FACTORS USED IN THIS REPORT

The following abbreviations and symbols are used. Standard chemical symbols for elements, for example, Au, gold; Cu, copper; Fe, iron; U, uranium

PGE: Platinum-group elements--minerals and alloys

REE: Rare-earth elements

mm, cm, m, km: millimeter, centimeter, meter, kilometer

g, kg, t: gram, kilogram, tonne

g/t, g/m^3: grams per metric ton, grams per cubic meter

tonne: metric ton

%: percent

sq: square

The following conversion factors were used to convert weight and volume from U.S. Customary to metric quantities:

1 cubic yard = 0.765 cubic meter

1 troy ounce per short ton = 34.29 grams per metric ton

1 part per million = 1 gram per metric ton

1 pound = 0.454 kilogram

1 troy ounce = 31.10 grams

1 short ton = 0.907 metric ton

1 flask (76.0 pounds mercury) = 34.7 kilograms

SUMMARY OF VOLCANOGENIC MASSIVE-SULFIDE AND RELATED LODE DEPOSITS OF ALASKA

BROOKS RANGE

The northwestern Brooks Range contains several sedimentary exhalative Zn-Pb deposits and one bedded-barite deposit (map, table 1). The southern flank of the central Brooks Range contains an extensive suite of major Kuroko massive-sulfide deposits and one major carbonate-hosted Kipushi copper-lead-zinc deposit. Significant lode mineral deposits in the Brooks Range and Seward Peninsula are further summarized by Einaudi and Hitzman (1986).

rocks of the Precambrian or early Paleozoic Keevy Peak Formation and Middle Devonian to Lower Mississippian Totatlanika Schist (Wahrhaftig, 1968; Gilbert and Bundtzen, 1979). The Kuroko massive-sulfide deposits are interpreted as having formed during Devonian submarine volcanism (Nokleberg and others, 1987, 1988).

SOUTHERN ALASKA

The southern Alaska Range, in southern Alaska, contains two significant Besshi massive-sulfide deposits, Shellabarger Pass to the southwest and Denali to the east (map, table 1). The Shellabarger Pass deposit consists of a very fine grained mixture of mainly pyrite and marcasite and lesser sphalerite, chalcopyrite, galena, and pyrrhotite in carbonate-rich beds and as fracture fillings in Triassic or Jurassic chert and siltstone and associated pillow basalt (Reed and Eberlein, 1972). The Denali deposit consists of stratiform bodies of very fine grained and thin-layered chalcopyrite and minor pyrite in thin-bedded, shale-rich calcareous argillite enclosed in the Upper Triassic Nikolai Greenstone (Stevens, 1971; Seraphim, 1975).

In the eastern Chugach Mountains, Besshi and Cyprus massive-sulfide deposits in the Prince William Sound district along the eastern and northern margins of the Gulf of Alaska are Beatson, Copper Bullion, Ellamar, Fidalgo-Alaska, Knight Island, Latouche, Midas, Pandora, Schlosser, Standard Copper, and Threeman (map, table 1). Midas, the northernmost deposit, is in the southern part of the Valdez Group, which in this area consists of metamorphosed and deformed Upper Cretaceous flysch and greenstone derived from basalt. The other deposits to the south are in the Orca Group. Most of the deposits are classified as sediment-hosted Besshi massive-sulfide deposits; Knight Island, Standard Copper, and Threeman are basalt-hosted deposits classified as Cyprus massive-sulfide deposits (table 1). The Orca Group, which hosts most of the deposits, consists of a strongly deformed, thick assemblage of Paleocene and Eocene graywacke, argillite, minor conglomerate, pillow basalt, basaltic tuff, sills, and dikes (Winkler and Plafker, 1981), part of the Prince William terrane (map).

SOUTHEASTERN ALASKA

The geology of southeastern Alaska is varied and complex. In this report, southeastern Alaska is divided into three north-northwest-trending regions: the Coast Mountains region, central southeastern Alaska, and coastal southeastern Alaska (map). The Coast Mountains region consists of the informally named Coast plutonic-metamorphic complex of Brew and Ford (1984a, b), which is approximately equivalent, from east to west, to part of the Stikinia terrane, to all of the Tracy Arm and Taku terranes, and to part of the Gravina-Nutzotin belt (Monger and Berg, 1987). Central southeastern Alaska consists of the Alexander belt (Brew and others, 1984), which is approximately equivalent to the Alexander terrane (Monger and Berg, 1987). Coastal southeastern Alaska consists of the Kelp Bay Group and similar unnamed rocks, both part of the Wrangellia terrane (Monger and Berg, 1987), and the Sitka Graywacke and similar unnamed rocks, part of the Chugach terrane (Monger and Berg, 1987).

The mineral occurrences, deposits, and mines within this complex geologic region are likewise a complex, including a variety of volcanogenic massive-sulfide deposits (Berg and others, 1981; Berg, 1984). The Coast Mountains region contains an extensive suite of metamorphosed sulfide deposits and one Besshi massive-sulfide deposit. Central southeastern Alaska contains extensive suites of Kuroko massive sulfide, bedded barite, and metamorphosed sulfide deposits. Coastal southeastern Alaska contains no known significant volcanogenic massive-sulfide or related lode deposits.

Coast Mountains Region

Metamorphosed sulfide deposits present in the Coast Mountains region are Sweetheart Ridge, Sumdum, Groundhog Basin, Alamo, Mahoney, Moth Bay, Reliance, and Red River (map, table 1). The metamorphosed sulfide deposits are widespread and occur along a strike length of about 300 km. The deposits consist of stratabound, massive to disseminated sulfide minerals hosted by moderately to highly metamorphosed and deformed volcanic and sedimentary rocks. Original or primary features of the deposits have been so obscured by metamorphism and deformation as to preclude classification into a more specific deposit type. Some of the deposits may be metamorphosed Kuroko massive-sulfide deposits, as indicated by high lead and silver concentrations, and the presence of metamorphosed felsic volcanic rocks. All but one of the deposits are in the western metamorphic zone of the informally named Coast plutonic-metamorphic complex of Brew and Ford (1984a, b), west of the foliated tonalite sill, in the Taku terrane (map). The Red River deposit is in the central part of the Coast plutonic-metamorphic complex in the Tracy Arm terrane. Substantial amounts of copper, lead, zinc, and silver are present in these deposits. The Groundhog Basin deposit contains an estimated several hundred thousand tonnes grading 8 percent Zn, 1.5 percent Pb, and 51.5 g/t Ag. The Moth Bay deposit contains an estimated 91,000 tonnes grading 7.5 percent Zn and 1 percent Cu and an additional estimated 181,000 tonnes grading 4.5 percent Zn and 0.75 percent Cu.

Central Southeastern Alaska

The major significant volcanogenic massive-sulfide and related lode deposits in central southeastern Alaska are (1) the Kuroko massive-sulfide deposits of Glacier Creek, Orange Point, Greens Creek, Pyrola, Kupreanof Island, Helen S., Zarembo Island, Khayyam, Niblack, Barrier Islands, and Driest Point; (2) the metamorphosed sulfide deposits of Cornwallis, Copper City, and Moonshine; and (3) the bedded-barite deposits of Castle Island and Lime Point (map, table 1). Some of the bedded-barite deposits, such as Castle Island, may be related to Kuroko massive-sulfide deposits. These deposits in central southeastern Alaska are hosted principally by Paleozoic and early Mesozoic metasedimentary, metavolcanic, and metaplutonic rocks of the Alexander belt (Brew and others, 1984), which is approximately equivalent to the Alexander terrane. This unit consists mainly of Ordovician or older(?) carbonate rocks, carbonaceous flysch, chert, terrigenous and marine clastic rocks; Ordovician to Triassic metamorphosed basaltic to silicic flows and related volcaniclastic rocks; and Ordovician and Silurian diorite and trondhjemite. Younger plutonic rocks in the Alexander belt consist of Jurassic granite, Cretaceous granodiorite, Mesozoic (mainly Cretaceous) pyroxenite, gabbro-norite, and gabbro, and Tertiary granite, granite porphyry, and felsic dikes.

Substantial amounts of copper, lead, zinc, barium, silver, and gold occur in, or have been produced from, the Kuroko massive-sulfide deposits and bedded barite in central southeastern Alaska (Nokleberg and others, 1987). The Glacier Creek deposit contains an estimated minimum 680,000 tonnes grading as much as 3 percent combined Cu and Zn and as much as 45 percent $BaSO_4$. The Khayyam deposit produced about 6.4 million kg Cu, 40,120 g Au, and 53,200 g Ag from 205,000 tonnes of ore. The Niblack deposit produced about 636,000 kg Cu, 34,200 g Au, and 466,500 g Ag. The Greens Creek deposit, which is scheduled to begin production in 1988, contains an estimated 3.6 million tonnes grading 0.4 percent Cu, 2.7 percent Pb, 8.0 percent Zn, 360 g/t Ag, and 3.4 g/t Au (table 1). These Kuroko massive-sulfide deposits in central southeastern Alaska extend more than 300 km along the strike length of the Alexander belt.

Cornwallis, Copper City, and Moonshine in central southeastern Alaska are metamorphosed sulfide deposits in carbonate and metavolcanic host rocks. The Copper City deposit produced about 1,450 tonnes of ore, and the Moonshine deposit produced about 46,500 g Ag (table 1); no model is available to classify these two deposits. Bedded-barite deposits in central southeastern Alaska are Castle Island and Lime Point. The Castle Island deposit produced 680,000 tonnes of ore grading 90 percent $BaSO_4$. The Lime Point deposit contains an estimated 4,500 tonnes grading 91 percent barite.

ACKNOWLEDGMENTS

We thank numerous colleagues, listed as contributors, in private industry, universities, the U.S. Geological Survey, the Alaska Division of Geological and Geophysical Surveys, and the U.S. Bureau of Mines for contributing the data published in Nokleberg and others (1987, 1988), the sources of data for this study. We also thank Ed DeWitt and D.M. Sheridan for constructive and helpful reviews.

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CONTRIBUTORS ON SPECIFIC DEPOSITS OR REGIONS
[Affiliations at time of contribution]

Joseph A. Briskey - U.S. Geological Survey
William P. Brosge - U.S. Geological Survey
John T. Dillon - Alaska Divison of Geological and Geophysical Surveys, Fairbanks, Alaska
John Dunbier - Noranda Exploration, Incorporated, Anchorage, Alaska
Inyo F. Ellersieck - U.S. Geological Survey
Curtis J. Freeman - Onyx Exploration, Incorporated, Fairbanks, Alaska
D.R. Gaard - Resource Associates of Alaska, Incorporated, Fairbanks, Alaska
Murray W. Hitzman - Chevron Resources Company, San Francisco, Calif.
Ian M. Lange - Department of Geology, University of Montana, Missoula, Mont.
Christopher D. Maars - Anaconda Minerals Company, Anchorage, Alaska
J.S. Modene - Cominco Alaska, Incorporated, Anchorage, Alaska
David W. Moore - Cominco, Incorporated, Anchorage, Alaska
Clint R. Nauman - Research Associates of Alaska, Incorporated, Fairbanks, Alaska
Steven R. Newkirk - Research Associates of Alaska, Incorporated, Fairbanks, Alaska
Steven H. Nelson, U.S. Geological Survey
Harold Noyes, Doyon, Limited, Fairbanks, Alaska
Joseph T. Plahuta - Cominco Alaska, Incorporated, Anchorage, Alaska
Charles M. Rubin - Anaconda Minerals Company, Denver, Colo.
D.A. Scherkenbach - Noranda Exploration, Incorporated, Anchorage, Alaska
Jeanine M. Schmidt - U.S. Geological Survey
P.R. Smith - U.S. Borax and Chemical Corporation, Spokane, Wash.
J.E. Stephens - U.S. Borax and Chemical Corporation, Spokane, Wash.
Loren E. Young - Cominco Alaska, Incorporated, Anchorage, Alaska

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